Relationships Between Sapling Recruitment and Canopy Gaps in Waldron Fen, Emmet County, MI

Kaitlynn Forde, Janice Ho, Megan McConnell, Paul McKeighan

University of Michigan Biological Station

EEB 381: General Ecology
6/11/13

Joel Heinen, Alejandro Garcia-Lozano, Edward Metzger

Abstract

The purpose of our experiment was to determine the relationship between canopy cover and the density of seedlings and saplings in an aging Scotch pine (*Pinus sylvestris*) plantation in Emmet County, Michigan. For this experiment, we marked off a total of 24 4 x 4 m plots through randomly generated coordinates, to record seedling density and sapling height and density. In the middle of each plot, a spherical densiometer was used to measure canopy cover. Linear regressions were used in order to determine the relationships between canopy cover and seedling density, sapling density, and sapling height. The results indicate a significant negative correlation between seedling density and canopy cover after excluding one outlier plot from our data. There is also a significant negative correlation between sapling density and canopy cover, but only a weak correlation between sapling height and canopy cover. Our findings suggest that seedling and sapling density increase as a result of less canopy cover.

Introduction

Waldron Fen is a 59 hectare property owned by the Waldron family, who removed development rights from their property in an effort to maintain it as a bird sanctuary and preserve the natural character of the land (Little Traverse Conservancy, 2002). It is located about 32 km southwest of the University of Michigan Biological Station, in Emmet County, Michigan. Part of the property was used as a Christmas tree plantation by the previous owner (Bermudez *et al*, 1997). The conifers originally planted for the Christmas tree plantation are still present, although there have been plans to remove many of them and replace them with scrub ground cover found in surrounding wetlands (Bermudez *et al*, 1997).

Within the Waldron Fen plantations, two main species of trees exist: Scotch pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*). For our study, we focused on the Scotch pine plantation as it had greater light availability based on initial observations.

The Scotch pine thrives in an acidic environment. Its optimal pH ranges from 4.5 to 5.2, but it can tolerate a range of 4.5 to 6.0 (Greenwood and Lowe, 2006). Scotch pines grow under a wide variety of conditions, including extreme cold and hot temperatures (Burns and Honkala, 1990). The Scotch pine also thrives in dry conditions by establishing deep roots in order to outcompete other vegetation (Burns and Honkala, 1990). However, Scotch pine seedlings are shade intolerant. Therefore, successful germination and growth of a seedling is uncommon in areas of dense canopy cover (Burns and Honkala, 1990).

Germination and seedling growth greatly depend on gaps in the canopy for access to sunlight (Cooley and Wolosin, 2002). When a canopy gap forms, the dynamics of the understory change with the additional light resource. This enables the trees that are fast-growing and good competitors to sprout and form the next generation canopy (Cooley and Wolosin, 2002).

Therefore, we predict that seedling recruitment will be greater in areas with less canopy cover. Furthermore, we predict that saplings will be more abundant and have a higher average height in areas with less canopy cover.

Materials & Methods

Our research site was the Scotch pine plantation, roughly 1.4 hectares in size (270 x 52 m). The plantation was divided lengthwise into two east-to-west transects. To ensure random sampling representative of the whole plantation, we overlaid a coordinate system using Google Maps and a random number generator. Each plot within the two transects was given a fixed latitude, spaced 20 m apart, and a random longitude. We mapped a total of 24 plots, with 12 in each transect (Figure 1).

In the field, measurements started at the north-eastern end of the northern transect. The latitude of each plot was found using a 100 m measuring tape, and a 25 m measuring tape was used to reach the random longitude for the placement of the northeast corner of the plot, which was marked by a flag. The other corners were measured, each 4 m from the last, in the order of southeast, southwest, and northwest and marked with flags. A compass was used to ensure that the plots were square and in line with the cardinal directions. After each plot's corners were flagged, a measuring tape was stretched diagonally across each plot to find and flag the center of the plot. The same procedure was applied for the southern transect.

For each plot, we recorded the number, species, and size of trees as well as the density of overstory coverage. For mature (i.e. overstory) trees, we recorded the species and diameter-at-breast-height (DBH). For saplings (trees over 1 m, but not canopy height), we recorded each one by species and height. A 1 m^2 PVC pipe was used to mark out 1 m^2 plots in the four corners of the plot. Within each 1 m^2 plot, seedlings (trees under 1 m in height) were recorded by species number of individuals.

The overstory coverage was estimated as a percentage using a spherical densiometer. For each plot, we took a densiometer reading at the center of the plot, facing each of the cardinal directions. The densiometer was photographed at each position to eliminate errors from movement, and the four readings were averaged.

Results

Our 24 plots ranged from 55.80 to 90.12% canopy coverage, with a mean of 78.65%. Seedling density spanned a range from 0 to 13.75/m^2, with a mean of 5.71/m^2. Seedling species were predominantly Norway spruce (*Picea abies*) and Douglas fir (*Pseudotsuga menziesii*), but also included black cherry (*Prunus serotina*), American beech (*Fagus grandifolia*), Scotch pine (*Pinus sylvestris*), and red maple (*Acer rubrum*) (Table 1). Sapling species were primarily Norway spruce, but also included black cherry, Scotch pine, box elder (*Acer negundo*), and balsam fir (*Abies balsamea*) (Table 2). There were between 0 and 5 mature canopy trees per plot, which consisted almost entirely of Scotch pine, but also included several Norway spruce.

To determine significant correlations, multiple linear regression tests were performed. Linear regression analysis of seedling density versus canopy cover is not statistically significant ($R^2 = 0.054$; F = 1.248; sig. = 0.276) (Figure 2). The sapling density versus canopy cover linear regression analysis gives a significance of 0.003 ($R^2 = 0.336$; F = 11.156) (Figure 4). Linear regression analysis of sapling height versus canopy is not statistically significant ($R^2 = 0.093$; F = 2.266; sig. = 0.146) (Figure 5).

Discussion

Although the correlation between seedling density and canopy gaps was not statistically significant, it becomes significant after excluding one plot (Figure 2). Plot 20 seems to have a disproportionate effect on the trend line. It has an average of 1 seedling per m^2 and canopy coverage of 55.8%. Thus, even though the canopy coverage is the lowest of all plots, the seedling density is the lowest of any non-zero plot. Seedlings and developing trees compete for light and space. As they grow, saplings reduce the light available to the ground so fewer seedlings can be established.

The data gathered reflect this phenomenon. The mean number of total saplings per plot (for all plots) is 3.63, with a standard deviation of 5.72. Therefore, we can say that 99.73% of similar communities would have between 0 and 20.79 saplings per plot. Plot 20 is an outlier with 22 saplings. A linear regression analysis of seedling density versus canopy cover excluding plot 20 yields a statistically significant correlation ($R^2 = 0.300$, $F = 8.994$, sig. = 0.007) (Figure 3). This supports our hypothesis that seedling density and canopy cover have a negative relationship, and provides insight as to the effect of light on seedling growth in an established forest.

There was a significant, negative correlation between sapling density and canopy cover (Figure 4), which supports our hypothesis. This was expected as canopy gaps provide sunlight for the understory. As the percentage of canopy cover decreases, there is more light available to the seedlings which enables them to grow into saplings.

The relationship between sapling height and canopy cover was not significant, thus failing to support this hypothesis. One possible explanation is that canopy gaps are created at different times, resulting in variation of seedling and sapling age. Thus, canopy coverage would have a weaker correlation with sapling height. To control for sapling age, we would have to measure canopy cover and sapling height over time, which was beyond the scope of this study.

In this experiment, several factors may have affected our results. The densiometer readings neglected the coverage created by saplings, thus not accounting for sunlight availability to seedlings. Our seedling counting methodology could have also affected our results, since we only collected data from four corners of the plot, which could be unrepresentative of the plot as a whole. For example, if a specific corner contained a mature tree trunk or an abundance of saplings, the average amount of seedlings would decrease.

Human error may have led to inconsistencies in this experiment. Seedlings could have been miscounted, especially in the presence of saplings, as their lower branches could prevent seedlings from being seen. Additionally, more care could have been taken when measuring plot boundaries to ensure consistent sampling area. Inconsistent plot measurements could have led to inclusion or exclusion of additional seedlings or saplings, thus altering the results.

As noted above, part of our difficulty came from splitting our data into seedlings and saplings, but only measuring the height of the saplings. If instead, we measured the height of every non-canopy tree, then we would have other data to compare plots with. The relative "success" of sapling-dominated plots would be demonstrated with this method, rather than appearing to have lower development in plots with less canopy coverage. This would be the ideal method for consequent studies.

Conclusion

Our findings support the trend between decreasing canopy cover and increasing seedling recruitment. Additionally, the data support the correlation between decreasing canopy cover and increasing sapling density. Although the data support the relationship between increasing sapling height and decreasing canopy cover, this trend was not significant. These trends emphasize the significance of light availability in successional plant communities and the dynamics of competition in the presence of canopy gaps. Based on our data, we can predict that the removal of canopy trees leads to the establishment of seedlings in a greater density that survive to become saplings. Widespread removal of exotic monoculture canopy tree populations could facilitate their replacement by native species.

Acknowledgements

We thank the Waldron family for allowing us access to Waldron Fen to conduct this study. We also thank the Biological Station for providing us with the equipment that made this study possible. Finally, we thank Dr. Joel Heinen, Alejandro Garcia-Lozano, and Edward Metzger for guiding and supporting us in this study.

References

Anon. 2002. "Waldron Fen Protected Birds and Bird Lovers Both Benefit". Little Traverse Conservancy. Web. 22 May 2013. http://www.landtrust.org/Newsletters/Summer2002Newsletter/WaldronFenProtected.htm.

Bermudez, R., M. Carling, A. Gulley, J. Roof, and A. Snider. 1997. Conservation management plan for Waldron Fen, Emmet County, Michigan. *Deep Blue*, 1997. Web. 22 May 2013. http://deepblue.lib.umich.edu/handle/2027.42/54706.

Burns, R. M. and B. H. Honkala. 1990. *Silvics of North America*. Washington: U.S. Dept. of Agriculture, Forest Service. Web. 22 May 2013. http://www.na.fs.fed.us/pubs/silvics_manual/Volume_1/pinus/sylvestris.htm.

Cooley, A. and M. Wolosin. 26. Nov. 2002 Canopy Gap Dynamics. 26 Nov. 2002. Web. 22 May 2013. http://biology.duke.edu/bio265/msw10/gaps1.html.

Greenwood, J. L. and R. L. Lowe. 2006. The Effects of pH on a Periphyton Community in an Acidic Wetland, USA. *Advances in Algal Biology: A Commemoration of the Work of Rex Lowe*. Springer. New York. 72-82.

Appendix

Figure 1: Diagram of Waldron Fen plantation and sampling plots

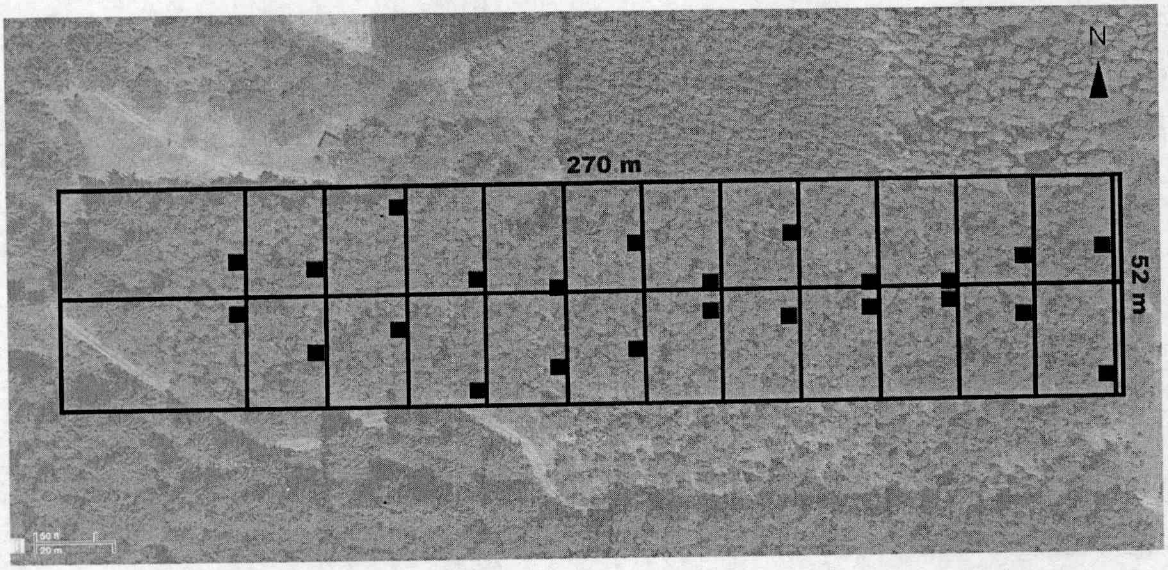

Figure 2: Linear Regression showing the Relationship between Seedling Density/m^2 and Canopy Coverage (significance = 0.276)

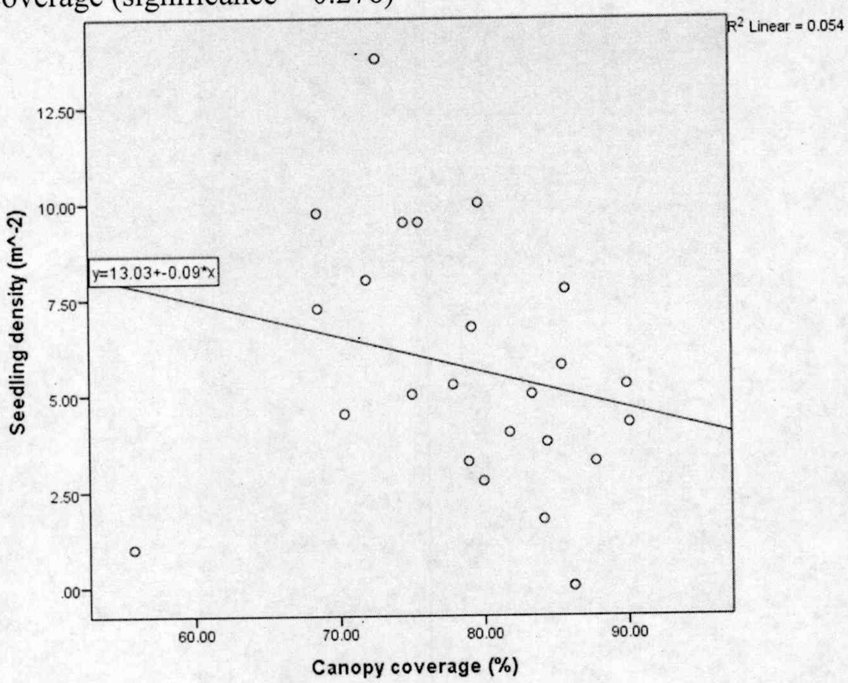

Figure 3: Linear Regression showing the Relationship between Seedling Density/m^2 and Canopy Coverage with plot 20 removed (significance = 0.007)

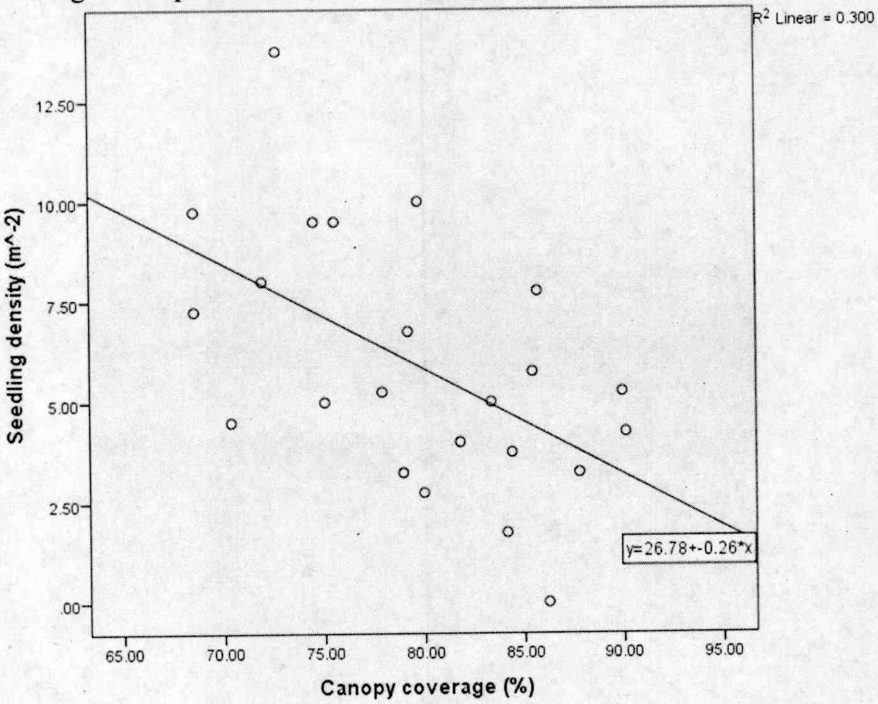

Figure 4: Linear Regression showing the Relationship between Sapling Density per plot and Canopy Coverage (significance = 0.003)

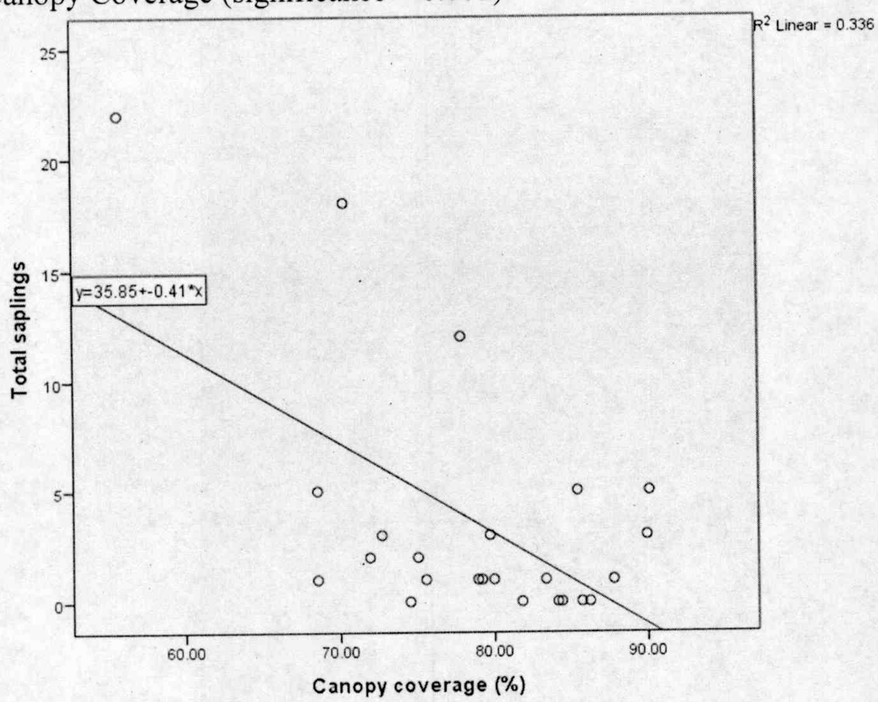

Figure 5: Linear Regression showing the Relationship between Average Sapling Height and Canopy Coverage (significance = 0.146)

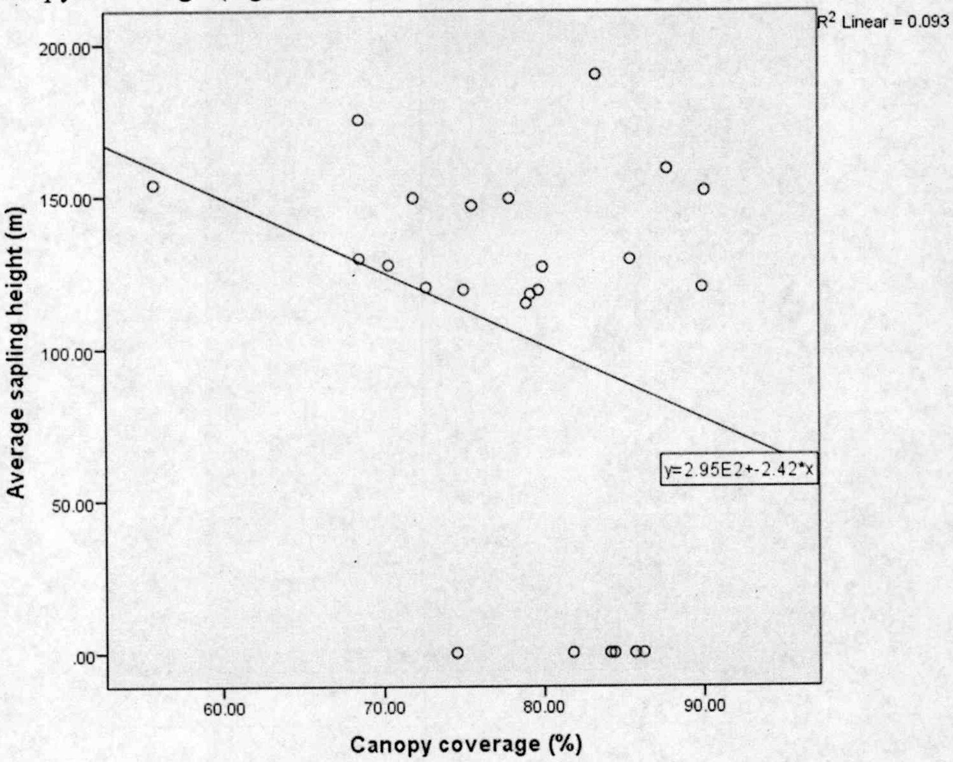

Table 1: Relative abundance of seedlings by species

Species	Norway spruce	Douglas fir	Black cherry	American beech	Red maple	Scotch pine
Total number	254	233	49	5	4	3
Percent of total	46.35	42.52	8.94	0.91	0.73	0.55

Table 2: Relative abundance of saplings by species

Species	Norway spruce	Black cherry	Balsam fir	Box elder	Scotch pine
Total number	76	14	7	2	1
Percent of total	76.00	14.00	7.00	2.00	1.00